ART. IX.—*On the Influence of Gravity on the Physical Condition of the Moon's Surface. By* BALFOUR STEWART, ESQ.

THE great irregularities of the surface of our satillite, are discernible almost without the aid of a telescope, but, by means of this instrument they have been accurately measured; and their stupendous character impressed upon the mind, which is thus enabled to compare them with the irregularities of the Earth's surface. The appearance presented by the moon's disc, is thus described by the Rev. Josiah Crampton, in his work entitled *The Lunar World; its Scenery, Motions, &c.*

"Not only," he remarks, "are her mountains more numerous in proportion to her size than those of the earth, but they are much larger, rising to a much loftier elevation, composed apparently of a substance of a much harder texture than any thing terrestrial, and exhibiting bolder and sharper outlines, and more tremendous precipices, some of which project and overhang each other in such a manner as to lead many to suppose that the rocks composing them are of a harder and more solid nature than wrought iron."

And the *Dublin University Magazine*, for February, 1854, remarks on the same subject.

"Some important diversity must prevail, no doubt, for it cannot be by chance, that in the lesser body sheer cliffs of thousands of feet descend from mountain tops into the valleys or chasms, while in the larger, no search has yet succeeded in discovering a perpendicular descent of five hundred feet anywhere. The moon's craters cling to the sides of cliffs, cut into, encompass, and over-leap each other. In dimensions some of them measure one hundred miles."

With regard to the cause of this diversity I would venture an explanation. I do not look for it in any difference of material; for I am neither inclined to imagine with some that the moon's surface has more tenacity than wrought iron, nor with others that it resembles cork. I would rather look for its chief cause in the difference between terrestrial and lunar gravitation. A long rod of iron will bend, and a sufficiently long rod of any brittle substance will break by its own weight; but if these be placed in circumstances where they retain their tenacity and all their other qualities unchanged, with the exception of their gravity, which is lessened, the rod of iron will not bend so much, and it will require a greater length of the brittle substance in order to break it. Now the weight of the same body is much less on the moon's surface than on the earth's. For the attraction of a sphere of matter on any point, without its force and distance, is the same as if all the matter of which the sphere is composed were collected in its centre. Now, if there be two spheres, of the same average density, the attraction of either for a point on its surface will be equal to that produced by the whole mass acting from the centre; and, since attraction varies inversely as the square of the distance, that on the point will vary as $\frac{\text{mass}}{\text{radius}^2}$ viz., it will vary altogether directly as the radius of the attracting sphere.

Now, according to Humboldt, the diameter of the moon is 1816 geographical miles, and the mean diameter of the earth is 6864 geographical miles; hence, supposing the density of these two bodies to be the same, these numbers will represent their proportional attraction for a point on their surface. But if the density of our earth be denoted by (1), that of the moon, (according to Humboldt), is only ·619; if, therefore, lunar gravitation be reckoned unity, terrestrial gravitation will be found from the following compound proportion:—

$$\begin{array}{lll} 1816 & : \; 6864 & :: \; 1 \\ \cdot 619 & : \; 1000 & \end{array}$$

The result of which is 6-1 for the value of terrestrial gravitation, or upwards of six times that of lunar gravitation. We need not therefore be surprised at matter remaining stable on the moon's surface, in a position from which it would be hurled by its own weight if on the earth's surface. And if we suppose that gravitation has exerted a direct influence in rounding the irregularities of the earth's surface, we need not be surprised if the moon's surface be less rounded, and more mountainous and irregular.

In like manner, were each square inch of the moon's surface charged with the same mass of atmosphere as the same extent of the earth's surface, its tension would be less, because its weight would be less. It would therefore be less condensed, and would not lie so closely to the surface as on our earth, but would spread to a greater distance from it.

Take a star near the edge of the moon. We may consider the star as a luminous point so distant that the rays which fall upon the eye form a parallel pencil in passing near the moon, and through its atmosphere, if there be any. But the mass of material particles which such a pencil will encounter in its passage through an atmosphere will vary, not only with the total mass of that atmosphere, but also with the manner in which the atmosphere is attached to the surface of the planet. The following approximate demonstration may serve to make my meaning plain.

Case 1*st.* Let the atmosphere (Fig. 1) be so closely attached to the surface, that its depth is very small compared with the radius of the planet. Let A B C be part of a great circle section of the planet, let A' B' be the boundary of the atmosphere, and by an alteration of circumstances suppose this atmosphere afterwards extended to A" B". By this latter supposition the same amount of atmospherical particles will be included in the solid, represented sectionally by A A" B" B, as was formerly included in A A' B' B. But the solid A A" B" B is to the solid A A' B' B nearly as A A" is to A A', that is the amount of atmospherical particles included in a given space varies *(cæteris paribus)* inversely with the depth of the atmosphere. But the length of the pencil of light exposed to the action of the atmosphere varies nearly in proportion to the square root of the depth of the atmosphere, therefore the closer the atmosphere lies upon the surface, the greater will be the mass of particles which the pencil has to encounter.

Case 2*nd.* Suppose (Fig. 2nd) that the depth of the atmosphere is very great in comparison with the radius of the planet. Here the solid A A' B' B is to A A" B" B very nearly as $(A\ A')^3 : (A\ A'')^3$ or as the cube of the depth of the atmosphere, but the length of a pencil of light passing near the planet immersed in the atmosphere will vary directly with the depth of atmosphere, hence in this case also, the deeper the atmosphere the fewer particles will the pencil encounter. These are the two extreme cases, and perhaps this demonstration is accurate enough to entitle us to conclude that when a given mass of atmosphere is closely attached to a planet, a pencil of light passing close to the surface will encounter a greater mass of particles, and probably deviate more from its direct course, or in some other manner indicate the existence of an atmosphere than when the same mass of atmosphere is more loosely attached. If, therefore, each square inch of the moon's surface were charged with the same mass of atmosphere as the same extent of the earth's, it would not *(cæteris paribus)* cause a star to deviate so much as the terrestrial atmosphere. It might also be shown (Fig. 3rd) that were the atmosphere in precisely the same state for both planets, the pencil would encounter more particles in the atmosphere of the larger body being immersed in it to a greater length. And, finally, if the amount of atmosphere be proportional to the mass of the planet, we canuot look for the same mass of atmosphere on each square inch of the moon's surface as on the same extent as our earth's. These

FIG 1

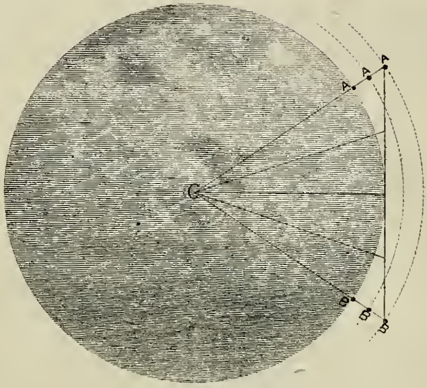


FIG 2

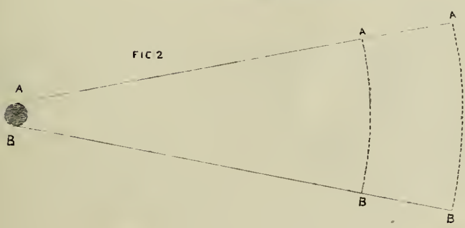
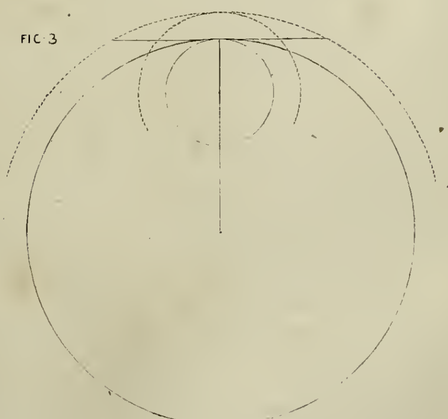


FIG 3



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